1. **Course title**: Fuzzy Evolutionary Hybrid Inference Systems

2. **Course code**: FEHIS

3. **Validity of course description**: 2017/2018

4. **Level of studies**: BA, BSc programme / MA, MSc programme lub 1st cycle / 2nd cycle of higher education

5. **Mode of studies**: intramural studies / extramural studies

6. **Field of study**: CEIE - Interdisciplinary Studies: Automatic Control and Robotics, Electronics and Telecommunications, Computer Science (FACULTY SYMBOL) RAU2

7. **Profile of studies**: comprehensive practical

8. **Programme**: all

9. **Semester**: 2

10. **Faculty teaching the course**: Faculty of Automatic Control, Electronics and Computer Science

11. **Course instructor**: Ph.D. Eng. Piotr Czekalski

12. **Course classification**: common courses

13. **Course status**: compulsory / elective

14. **Language of instruction**: English

15. **Pre-requisite qualifications**: Programming skills in at least one of the following languages: C#, Java, Matlab (semantic programming) are essential for the laboratory; Understanding of parallel programming issues and problems is suggested; Also suggested (however not necessary) general knowledge on Genetic Algorithms and Fuzzy Sets;

16. **Course objectives**: The main goal is to present audience a modern approach to the AI: automated learning systems. To obtain this goal, an in-depth review of the fuzzy inference systems, genetic algorithms and evolutionary strategies (may include neural networks as well) is presented as cooperating to constitute a hybrid approach to the machine learning. This course brings various opportunities to find valuable M.Sc. thesis' themes.

17. **Description of learning outcomes**:

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The student has in-depth knowledge on mathematical, analytical and algorithmic modelling of complex systems for various classes of numeric optimisation problems (both linear and non-linear) with means of heuristic approach. Ma pogłębioną wiedzę w zakresie matematycznych, analitycznych oraz algorytmicznych metod rozwiązywania różnych klas problemów optymalizacyjnych oraz budowy modeli i metod modelowania złożonych układów.</td>
<td>CL</td>
<td>Lecture and laboratory</td>
<td>T2A_W02</td>
</tr>
<tr>
<td>2</td>
<td>The student has advanced knowledge on inference methods and their application in analysis and implementation of the algorithms.</td>
<td>CL</td>
<td>Lecture and laboratory</td>
<td>T2A_W01, T2A_W03, T2A_W04</td>
</tr>
<tr>
<td>3</td>
<td>The student is capable of defining optimisation and simulation model for simple and complex systems and can optimise it for software and hardware implementation.</td>
<td>LE</td>
<td>Laboratory</td>
<td>T2A_W09</td>
</tr>
</tbody>
</table>

18. **Teaching modes and hours**

Lecture / BA /MA Seminar / Class / Project / Laboratory: 30 / 0 / 0 / 0 / 0 / 15

19. **Syllabus description**:

The lecture is performed in double intensity through the first half of the semester.
The first part of the lecture covers theoretical aspects on the popular models of the fuzzy inference systems, evolutionary strategies and genetic algorithms. The second part of the lecture present practical aspects of joining the presented methods to constitute machine learning (self-extracting / knowledge discovering) hybrid systems.

Presentation Plan:

1. Fuzzy sets theory review.
2. Fuzzy inference systems.
   2.1. Fuzzy relations and linguistics variables.
   2.2. If-then rules
      2.2.1. Fuzzy rules database and inference.
   2.3. Mamdani-Assilian FIS model
   2.4. Takagi-Sugeno-Kang FIS model
   2.5. Czogala-Le{ski} FIS with parameterized consequents.
3. Evolutionary techniques
   3.1. A mathematical model of mother nature.
   3.2. Genetic algorithms review.
      3.2.1. Introduction.
      3.2.2. Members coding/modeling.
      3.2.3. Fitness function and border conditions.
      3.2.4. Genetic operators.
      3.2.5. Reproduction and stop conditions.
   3.3. Evolutionary computing.
      3.3.1. Introduction.
      3.3.2. Evolutionary strategies.
      3.3.3. Fitness function and border conditions.
      3.3.4. Members coding/modeling.
      3.3.5. Evolutionary operators.
   3.4. What is a difference between GA and EA?
4. Fuzzy-evolutionary techniques.
   4.1. Fuzzy database learning models review.
      4.1.2. Pittsburgh approach.
      4.1.3. Iterative learning.
   4.2. Data mining for fuzzy rules – system learning.
      4.2.1. Three stage Mamdani-Assilian FIS fuzzy rules extraction.
      4.2.2. Two-stage Takagi-Sugeno-Kang FIS fuzzy rules extraction.
      4.2.3. Fuzzy Inference System with parameterized consequent fuzzy rules extraction.
5. Experiment design.
   5.1. Training data set and validation data set.

Labs:

1. Labs on with the fuzzy inference systems using Matlab Fuzzy Logic Toolbox and C++ / C# libraries (as choosen by students and their programming experience).
2. Labs on implementing various models of the hybrid inference systems using C++ / C# or Matlab.
3. Code optimization with respect to the parallel processing (multithreaded / nVidia cuda).

20. Examination: none

21. Primary sources:

   as position 5 but in english.
22. Secondary sources:


23. **Total workload required to achieve learning outcomes**

<table>
<thead>
<tr>
<th>Lp</th>
<th>Teaching mode :</th>
<th>Contact hours / Student workload hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lecture</td>
<td>30/30</td>
</tr>
<tr>
<td>2</td>
<td>Classes</td>
<td>0/0</td>
</tr>
<tr>
<td>3</td>
<td>Laboratory</td>
<td>15/45</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td>/</td>
</tr>
<tr>
<td>5</td>
<td>BA/MA Seminar</td>
<td>/</td>
</tr>
<tr>
<td>6</td>
<td>Other</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>Total number of hours</td>
<td>45/75</td>
</tr>
</tbody>
</table>

24. **Total hours:** 120

25. **Number of ECTS credits:** 4

26. **Number of ECTS credits allocated for contact hours:** 2

27. **Number of ECTS credits allocated for in-practice hours (laboratory classes, projects):** 2

26. **Comments:**

Lecture credit: presence is obligatory.

Laboratory: performing all exercises and documenting results, obtaining positive grade on each laboratory, presence during laboratory and active. This subject usually brings various possibilities to extend laboratory work/projects into the M.Sc. thesis as job done here is classified as pure research.
Approved:

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(date, Instructor's signature)

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(date, the Director of the Faculty Unit signature)